Automated evidence gathering

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Motivation

In-close approach change (ICAC) is an example of an issue that is studied by Flight Operations Quality Assurance Programs (Flight Safety Foundation, 1998) and Aviation Safety Action Programs (Steenblick, 2000). A thorough study of such an issue would require analysis of a large amount of data involving many events. Such a study could last over a period of months. Gathering of evidence supporting or refuting cause and effect hypotheses is a time-consuming part of such study. We are planning to develop Automated Evidence Gathering (AEG) system that would automate this process of gathering evidence thereby saving the analysts significant amount of time and improving the quality of analysis.

Architecture

AEG system would consist of four types of agents: user interface agents, a textual evidence gatherer agents (TEGA), a non-textual evidence gatherer agents (NEGA) and an evidence organizer agent. An user interface agent would acquire information about issues of user's interest and communicate a request for evidence related to the issue to other agents. Request for evidence may also come from data analysis programs. Textual evidence gathering agents and non-textual evidence gathering agents collect evidence related to these issues continuously and report it to the Evidence Organizer agent that, in turn, organizes this information in an easy to navigate, hyper-linked format on a web site that is personalized for each user. Users can visit this web site anytime to access evidence information during the period when the issue is being studied. Agents are autonomous, adaptive and they use standardized agent communication languages for communication. We will now discuss these system components in more detail.

AEG Components

User Interface

AEG user interface agent captures information about the issue of user's interest and a set of contextual conditions either using a user interface or an application-programming interface used by data analysis programs. Information about the issue includes hypotheses about causes and effects. Contextual information includes details of the analyst, airspace operational context, aircraft operational context and preferences about airports. Analyst information consists of job title, carrier, contact information and email. Airspace operational context consists of airspace, weather, light/visibility and ATC/advisory. Aircraft operational context consists of Operator, Mission, Flight Plan, Flight phase, control status. Airport preferences may indicate analysts interest in a specific airport or a set of airports. The system may infer some or all of this information without having to interact with the user based on the knowledge of user's carrier, user's past history and possibly other documentation of the specification of the issue.

In the case of ICAC, the acquired information includes consequences of ICAC and factors aggravating the consequences. Hypothesized consequences may include unwanted consequences, such as lateral and vertical navigation deviations, traffic conflicts, unstable approaches, hard landings, or aircraft damage. Hypothesized factors that make negative consequences more likely may include ATC policies, actions of individual pilots and controllers, air carrier policies, aircraft type, and airport characteristics. Study teams from different airlines studying the same problem may have different preferences as well as different access privileges.

Textual evidence gathering agent

This agent retrieves relevant textual reports supporting or refuting relevant cause and effect hypotheses. It then augments these reports with supplemental data such as ATC, weather, flight and other aviation data. Finally, it summarizes the reports into succinct summary to make it easy for the end user to comprehend presented evidence. In the ICAC example, this agent would gather reports supporting or refuting causal hypotheses from a variety of different data sources including ASAP, ASRS and accident/incident reports. Reports are typically subjective and may lack specific contextual information that could be critical in assessing the validity of a causal hypothesis. Integration of the report with supplemental data would make the report a valuable piece of evidence in the study. The number of relevant reports could possibly in hundreds, so the system would provide brief summaries of these reports in table format. Evidence gathering and summarization processes would be adapted to user's interest using machine learning and intelligent analysis techniques.

Non-textual evidence gathering agent

This agent identifies flight data/ATC data events of the kind identified in the issue of interest, quantifies associated contextual factors and quantifies the frequency and severity of consequences. It then uses statistical analysis to reveal if flights of interest differ in rates of particular types of consequences when compared with flights in general. This can provide evidence supporting or refuting hypotheses being studied. Like NEGA, TEGA evidence gathering and summarization would be adapted user's interests.

In the ICAC case, NEGA would first identify flights with approach and runway assignment changes during the arrival. Next, it would calculate the frequencies of exceedances making it possible to assess consequences for those flights. Analyses may reveal that while flights with change in approach and runway assignment do not differ in rate of exceedances, they differ on average and variability on several parameters during the approach. An example of a specific piece of evidence gathered from this kind of analysis is shown below:

"Flights experiencing a close-in change showed greater localizer deviation at 1,500, 1,000, and 500 ft. afe., were higher on the glideslope at 1,000 ft. and lower at 500 and 100 ft., and had greater nose-down pitch at 500 and 100 ft. These flights were more variable on the localizer throughout the approach, in airspeed and vertical speed at 500 and 100 ft., and N1 at 100 ft. (all probabilities < .01). Localizer and glideslope differences may need to be discounted among these flights as about one- third navigated visually to the new runway, rather than change ILS frequencies. " [Chidester, 2003]

Evidence Organizer Agent

SemanticOrganizer is a specialized knowledge management tool designed to enhance the information storage, organization, and access capabilities of distributed teams. Information in *SemanticOrganizer* is interlinked, to enable users to locate, track, and organize interrelated pieces of evidence. Linkages capture important semantic relationships among information resources in the repository, and these assist users in navigating through the information related to their studies. *SemanticOrganizer* provides a common electronic repository in which analysis team members can store and share information. It also provides an application-programming interface that allows data analysis software to access stored information. Evidence Organizer Agent would organize gathered evidence using SemanticOrganizer creating easy to navigate web pages. These pages would be personalized according to the user's interest profile and access privileges enabling effective use of it by the analysts while limiting use of any information to those authorized to view it. Thus, the evidence about the same issue may appear differently to study teams from different airlines. EvidenceOrganizer would also be accessible via API by data analysis programs.

Summary

Gathering evidence related to issues of interest is critical in a variety of aviation problem-solving activities. We are planning to develop a system called Automated Evidence Gathering System that would collect evidence in response to a request from API or a user query. This system consists of four agents: a user interface agent, textual evidence gathering agent, non-textual evidence gathering agent and evidence organizer agent.

References

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2. Enhancing Aviation Safety, ASAP. Jan Steenblick. Journal of the airline Pilots Association, Vol 69, Number 3, March 2000.